DECLARATION

I, Takao MARUYAMA, a Japanese Patent Attorney registered No. 8425, having my business office at SAM Bldg., 38-23, Higashi-Ikebukuro 2-chome, Toshima-ku, Tokyo 170-0013, Japan, solemnly and sincerely declare that I have a thorough knowledge of Japanese and English languages, that I made an English translation attached hereto, and that to the best of my knowledge and belief the translation is a true and correct reproduction of the original documents filed with the Japanese Patent Office in respect of Japanese Patent Application No. 2000-208928 on July 10, 2000 in the name of NEC Corporation.

Signed this 30th day of July, 2004

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JAPAN PATENT OFFICE

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Date of Application: July 10, 2000

Application Number: Patent Application No. 2000-208928

Applicant(s): NEC Corporation

April 20, 2001

Commissioner, Kozo Oikawa

Japan Patent Office

(Seal)

Certificate No. 2001-3032047

[Title of Document] Request for Patent

[Reference Number] 74610469

[Submitting date] July 10, 2000

[Address]

To Honorable Commissioner of the Patent Office

[International Classification] G02F 1/133

[Title of Invention]

DISPLAY DEVICE

[Number of Claims] 5

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[Indication of Charge]

[Ledger Number of Payment in Advance] 008707

[Amount of Payment] 21000

[List of Objects Submitted]

[Title of Object] Specification 1

[Title of Object] Drawings 1

[Title of Object] Abstract 1

[Number of Inclusive Power of Attorney] 9709418

[Necessity of Proof] Necessity

[Title of Document]

Specification

[Title of the Invention]

DISPLAY DEVICE

[Scope of Claim for a Patent]

[Claim 1] A display device of a hold type, which holds the brightness of the antecedent picture until the subsequent signal is input to a pixel, wherein:

a frame displaying one picture is time-divided into a plurality of sub-frames; and

the brightness of the subsequent sub-frame is attenuated at a prescribed rate according to the brightness of the input picture.

[Claim 2] A display device as claimed in claim 1, comprising:

a sub-frame generating means which time-divides a frame displaying one picture into a plurality of sub-frames;

an attenuation signal generating means for generating an attenuation signal by dividing an input brightness signal by a predetermined attenuation coefficient; and

a signal switching means for inputting the brightness signal before division to the antecedent sub-frame in the relevant frame, and inputting the attenuation signal after division to the subsequent sub-frame in the relevant frame.

[Claim 3] A display device as claimed in claim 2, wherein the attenuation signal generating means generates a signal by shifting the series of a digitalized brightness signal in the direction of a low order digit and eliminating the

digits underflowed due to the shift, and outputs the signal as an attenuation signal.

[Claim 4] A display device as claimed in claim 2 or 3 further comprising:

an integration means for integrating brightness signals for entire pixels, which form a picture in a frame; and

an attenuation coefficient generating means for generating an attenuation coefficient which varies according to an integrated value obtained.

[Claim 5] A display device as claimed in one of claims 2 to 4, further comprising:

a brightness classifying means for classifying the input brightness signal according to the brightness level; and

an attenuation coefficient generating means for generating an attenuation coefficient which varies according to a brightness range into which the brightness signal is classified.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a hold-type display device such as a TN (Twisted Nematic) type color LCD (Liquid Crystal Display), and more particularly, to a display device having a construction suitable for displaying a moving picture.

[0002]

[Prior Art]

The LCD, especially a TN (Twisted Nematic) type

color LCD, has come into widespread use in the field where CRT (Cathode Ray Tube) displays have been conventionally employed. However, it has been pointed out that the TN type LCD has an inclination to make a picture unclear and blurred or disordered in the case of displaying moving images. This inconvenient phenomenon occurs because the TN type LCD is a hold type display device which holds the brightness of the picture previously displayed until the next writing signals are inputted to pixels differently from impulse type display devices including CRTs and light projectors. More specifically, as shown in Fig. 12, in the impulse type display devices, a picture is displayed as pulse at the beginning of one frame for displaying a picture (image display period), and there is an interval to the next frame. In this way, the connection of adjacent pictures is cut off and the persistence of vision is adjusted, which prevents the picture from being unclear and blurred or disordered. On the other hand, in the hold type display device, a picture is held through one frame as shown in Fig. 13, and furthermore, on the occasion of transition to the next frame, rise and attenuation of brightness continue through the relatively long transitional period. For expel, when a moving picture whose one frame is 1/ 60 seconds and which changes in a high-speed is displayed consecutively, the persistence of vision reduces the visibility or visual recognition of the picture and lowers contrast. Thus, the picture becomes unclear and blurred or disordered.

Although the improvement of transient characteristic, which is found in the hold type display device, is said to be realized by an OCB (Optically

Compensated Bend) type LCD and a smectic LCD, the above-mentioned visual problem has not been solved.

[0003]

In an effort to solve this visual problem, a pseudo impulse system has been proposed, with which one frame of the hold type display device is time-divided into two sub-frames, and the subsequent sub-frame is not displayed as shown in Fig. 14. For instance, in the display devices disclosed in the Japanese Patent Application Laid-Open No. HEI 9-325715, No. HEI 11-202285 and No. HEI 11-202286, non-display periods are provided by turning a backlight or shutter on and off in one frame. In addition, in the display devices disclosed in the Japanese Patent Application Laid-Open No. 2000-19486 and No. 2000-19487, non-display periods are provided by changing the transmittance of a liquid crystal layer or turning a backlight on and off.

[0004]

[Problems that the Invention is to Solve]

When non-display period is provided within one frame as described above, however, transmission luminance energy per unit time is decreased and the overall brightness of a picture is extremely lowered. For example, letting the duty ratio of display period be 50 %, transmission luminance energy is reduced by half. The lowering of transmission luminance energy may be solved by improving the illuminance of a backlight. However, it requires lighting devices with high-illuminance and results in an increases in electric power consumption.

In order to solve the problems mentioned above, it is an object of the present invention to provide a display

device which prevents a moving picture from being unclear and blurred or disordered while suppressing the lowering of the brightness of the picture.

[0005]

[Means of Solving the Problems]

In accordance with the present invention, to achieve the object mentioned above, there is provided a display device of a hold type in which a frame displaying one picture is time-divided into a plurality of sub-frames, and the brightness of the subsequent sub-frame is attenuated at a prescribed rate according to the brightness of the input picture.

As just described, the brightness of the subsequent sub-frame of time-divided one frame is attenuated at a prescribed rate according to the brightness of the picture input to the antecedent sub-frame, and therefore, the display device of the present invention is able to prevent a moving picture from becoming visually blurred or disordered and unclear due to lowered contrast. Furthermore, since the brightness of the subsequent sub-frame is reduced but not totally eliminated, it is not necessary to have a lighting device with high-illuminance as a conventional pseudo impulse type display device in which the subsequent sub-frame is not displayed.

[0006]

It is preferable that the display device comprises a sub-frame generating means which time-divides a frame displaying one picture into a plurality of sub-frames, an attenuation signal generating means for generating an attenuation signal by dividing an input brightness signal by

a predetermined attenuation coefficient, and a signal switching means for inputting the brightness signal before division to the antecedent sub-frame in the relevant frame, and inputting the attenuation signal after division to the subsequent sub-frame in the relevant frame.

In the display device, the sub-frame generating means time-divides an original brightness frame (hereinafter referred to as original frame) into a plurality of sub-frames, the attenuation signal generating means generates an attenuation signal by dividing an input brightness signal by a predetermined attenuation coefficient, and the signal switching means inputs the brightness signal before division to the antecedent sub-frame and inputs the attenuation signal after division to the subsequent sub-frame. Thus, it is possible to achieve the object previously stated.

[0007]

It is preferable that the attenuation signal generating means generates a signal by shifting the series of a digitalized brightness signal in the direction of a low order digit and eliminating the digits underflowed due to the shift, thereby outputting the signal as an attenuation signal.

With the attenuation signal generating means, the division of the digitalized brightness signal can be easily executed by switching lines or using a shift register.

[0008]

The display device of the present invention may further comprise an integration means for integrating brightness signals for entire pixels, which form a picture of a frame, and an attenuation coefficient generating means

for generating an attenuation coefficient which varies according to an integrated value obtained.

The display device changes the attenuation coefficient according to the entire brightness of the picture of a frame. For example, in the case of the bright screen, the attenuation coefficient is made higher so that the subsequent sub-frame is relatively darkened. Thus, the picture is prevented from being visually blurred or unclear. Meanwhile, in the case of the dark screen, the attenuation coefficient is made lower and the subsequent sub-frame is relatively brightened. Thereby, it is possible to improve the visibility or visual recognition of the dark part of the picture.

[0009]

The display device may further comprise a brightness classifying means for classifying the input brightness signal according to the brightness level, and an attenuation coefficient generating means for generating an attenuation coefficient which varies according to a brightness range into which the brightness signal is classified.

In the display device of the present invention, suppression of the blur or unclearness of a moving picture between successive frames contradicts securing of picture contrast. In order to balance these two factors optimally, it is desirable to select the attenuation coefficient F carefully according to the brightness of a pixel or a screen. Taking this point into consideration, when classifying an input brightness signal according to the brightness level and generating an attenuation coefficient which varies

according to a brightness range into which the brightness signal is classified, it becomes possible to achieve a picture contrast with higher quality while preventing a moving picture from being unclear, blurred or disordered. The above-mentioned classification of brightness may be made with respect to the brightness of each pixel as well as the entire brightness of the picture of the relevant frame.

[0010]

[Embodiment of the Invention]

Referring now to the drawings, a description of preferred embodiments of the present invention will be given in detail. While, in the following description, a TN type active matrix color LCD device (hereinafter referred to as "LCD") is employed as an example of a display device, the LCD is cited merely by way of example and without limitation. It is obvious that the present invention is applicable to display devices of other types.

Fig. 1 is a schematic plane diagram showing the display section of the LCD used in the embodiments described below, and Fig. 2 is a schematic sectional diagram showing one pixel of the LCD.

The LCD is basically provided with a TFT (Thin Film Transistor) substrate 2 and a CF (Color Filter) substrate 3, which are oppositely disposed with a liquid crystal layer 1 between them.

Taking a plan view of the TFT substrate 2, in the display area Dp of a glass substrate 21, a plurality of scanning lines 22··· running in parallel with one another and a plurality of signal lines 23··· each of which intersects at right angles with each of the scanning lines are formed in

non-contacting relation, and at the areas surrounded by these lines, a matrix of pixels Px are formed. Each of the scanning lines 22 is extended to the outside of the display area Dp of the glass substrate 21 and connected to a scanning line driver 4. In the similar way, each of the signal lines 23 is extended to the outside of the display area Dp of the glass substrate 21 and connected to a signal line driver 5.

[0011]

Each pixel Px of the TFT substrate 2 is provided with a pixel electrode 24, a TFT 25 and a storage capacitor 26 as its main components.

Among these components, the pixel electrode 24 is a transparent electrode including ITO (Indium Tin Oxide). The pixel electrode 24 is opposed to a common electrode 32 also including ITO on the CF substrate 3 to form an electrode couple which drives the liquid crystal layer 1.

The TFT 25 comprises a gate electrode 251 extended from the scanning line 22, a drain electrode 252 extended from the signal line 23, a source electrode 253 extended from the pixel electrode 24, and a semiconductor layer 254 including amorphous silicon. The combination of these components forms an inversely staggered TFT.

The storage capacitor 26 is provided with a capacity electrode 261 extended from the pixel electrode 24 and a common capacity electrode 262 extended from the scanning line 22 to the area of relevant pixel Px with a gate insulation layer 27 between them. The electrostatic capacity is stored between the capacity electrode 261 and the common capacity electrode 262.

In each pixel Px of the CF substrate 3, a color filter layer 33 and black matrices 34 are formed between a glass substrate 31 and a common electrode 32. The color filter layer 33 has any one of three colors: red, green or blue, and is shaded from the light by the black matrices 34.

An orientation film 28 is formed on the surface of the TFT substrate 2 that contacts with the liquid crystal layer 1, and similarly, an orientation film 35 is formed on the surface of the CF substrate 3 that contacts with the liquid crystal layer 1. These two orientation films are arranged so as to intersect at right angles with each other. Consequently, the liquid crystal 1 becomes optically transparent when the electric field is unloaded.

[0012]

When, in the LCD, the scanning line driver 4 applies negative charge to the scanning lines 22 … from the first to the last in order, and the signal line driver 5 provides positive charge with the signal lines 23 … from the first to the last in order, the drain electrode 252 and the source electrode 252 conduct in the TFT 25 of the pixel Px at respective intersections. Thus, potential is generated between the pixel electrode 24 and the common electrode 32, and the liquid crystal layer 1 is driven. At the liquid crystal layer 1, the arrangement of liquid crystal molecules 11 varies according to the applied potential difference, and shading degree is enlarged as the potential difference is increased.

When preventing electricity from passing into a pixel Px, the TFT 25 comes into the nonconducting state. However, since the storage capacitor 26 holds potential by

storing static electricity, potential between the pixel electrode 24 and the common electrode 32 is held until the next rewrite signal is transferred, and the liquid crystal layer 1 maintains the current brightness (transmitted light volume). Thus, the LCD becomes a hold type display device.

[0013]

To the signal line driver 5 is input the brightness signal which controls the brightness of the concerned pixel. The brightness signal generally contains brightness information in the form of a digital signal. In the following embodiments, the digital signal is composed of a binary series having eight bits. When the brightness signal is input to the signal line driver 5, the signal line driver generates potential difference corresponding to the brightness signal, and transfers it to the concerned pixel Px. In the pixel Px, the liquid crystal layer 1 is driven by this potential difference, and transmitted light volume is changed according to the potential difference transferred. Thus, the gray scale (contrast) of the relevant pixel is determined. The 8-bit brightness signal produces 256 distinct shades on a gray scale.

[0014]

As described above, by charging the scanning lines and the signal lines sequentially, each pixel Px of the LCD expresses a picture whose brightness corresponds to the brightness signal. In the following embodiments, each frame (image display period) from the time the antecedent picture or image signal is input to the time the subsequent picture or image signal is input is 1/60 seconds. Since one frame is time-divided into two sub-frames in the following

embodiments, each frame from the time the antecedent picture signal is input to the time the subsequent rewrite signal is input is 1/120 seconds. In other words, all the LCDs of the following embodiments are driven by 120 hertz. It is needless to say that the drive frequency is given merely by way of example and without limitation, and the present invention is applicable to those LCDs with other drive frequencies.

[0015]

[First Embodiment]

Fig. 3 is a block diagram showing the control means which controls pictures of each pixel Px in a pixel area Dp in the LCD according to the first embodiment. In Fig. 3, the control means comprises an A/D converter 41, a control device 50, a frame buffer 42, a brightness power source 43, the scanning line driver 4 and the signal line driver 5.

The picture information which contains the brightness information on each color of red, green and blue transmitted in the form of analog signals and synchronization signals, is converted into digital signals DT by the A/D converter 41, and then input to the control device 50.

The control device 50 transmits a brightness signal Sc with respect to the respective colors of R, G and B (red, green and blue) to the frame buffer 42 which generates sub-frames as well as transmitting a generated vertical clock signal Sgt and scanning line starting signal Sg to the scanning line driver 4, and a generated horizontal clock signal Sdt and a signal line starting signal Sd to the signal line driver 5 together with a brightness signal Scl

containing the R, G and B brightness information, and an attenuation signal Sc2. The signal line driver 5 is fed with electric power from the brightness power source 43, converts the brightness signal Sc1 and the attenuation signal Sc2 into brightness control potential differences, respectively, and transmits them to the relevant pixel in the pixel area Dp.

[0016]

Fig. 4 is a block diagram of circuits, and Fig. 5 is a flow diagram of signal processing. As shown in the drawings, the control device 50 comprises a brightness judging circuit 51, an attenuation signal generating circuit 52 and a signal switching circuit 53.

Having received digital signals DT of picture information, the brightness judging circuit 51 recognizes a brightness signal Sc corresponding to one frame of each pixel in the pixel area Dp. At the same time, the brightness judging circuit 51 judges the brightness with respect to each color, and generates an attenuation coefficient F. In this embodiment, the attenuation coefficient F is a fixed value, and concretely, set at "4".

The brightness signals Sc for the respective colors are output to the frame buffer 42, and the attenuation coefficient F is output to the attenuation signal generating circuit 52.

[0017]

In order to distribute the input brightness signals Sc to the antecedent and the subsequent sub-fames, the frame buffer 42 saves the brightness signals Sc. At the same time, the frame buffer 42 generates two sub-frames by reading the

data 2 times faster than a period of one frame, and rereading the same data over again with a newly designated address for the subsequent sub-frame.

In this way, the frame buffer 42 outputs a double speed brightness signal Sc1 to the signal switching circuit 53 for the antecedent sub-frame (hereinafter referred to as "former sub-frame"), and, at the same time, outputs the same data to the attenuation signal generating circuit 52 for the subsequent sub-frame (hereinafter referred to as "latter sub-frame").

[0018]

The attenuation signal generating circuit 52, which is, for instance, composed of an LSI for processing operation, divides the brightness signal Sc1 input from the frame buffer 42 by the attenuation coefficient F (which is "4" in this embodiment) transmitted from the brightness judging circuit 51, and generates an attenuation signal Sc2. The attenuation signal Sc2 is output to the signal switching circuit 53.

[0019]

The signal switching circuit 53, which is composed of, for example, a multiplexer, distributes a brightness signal Sc1 input directly from the frame buffer 42 to the former sub-frame, and an attenuation signal Sc2 input from the attenuation signal generating circuit 52 to the latter sub-frame, thus outputting the brightness signals to the signal line driver 5.

[0020]

Signal flow of the first embodiment is described in Fig. 5. A picture or image signal containing the brightness

information of respective colors of R, G and B for one frame, which is input in the form of an analog signal, is input to the A/D converter 41, and converted into a digital signal DT. The brightness with respect to each color is read at the brightness judging circuit 51 of the control device 50, and speed of the brightness signal Sc of respective colors of R, G and B, is doubled at the frame buffer 42. Thereafter, the brightness signal Sc1 for the former sub-frame is allocated to the former sub-frame by the signal switching circuit 53.

The brightness signal Sc1 with respect to each color for the former sub-frame is converted into brightness control potential difference by receiving power feeding from the brightness power source 43 at the signal line driver 5, transmitted to the concerned pixel in the pixel area Dp, and controls the orientation of the liquid crystal molecules at the former sub-frame.

On the other hand, at the frame buffer 42, the brightness signal Sc1, whose speed has been doubled in the same frame, is recalled, and transmitted to the attenuation signal generating circuit 52. At the attenuation signal generating circuit 52, the brightness signal Sc1 is divided by the attenuation coefficient F (= 4) output from the brightness judging circuit 51 as follows:

$$Sc2 = Sc1/4$$

and generates an attenuation signal Sc2 which contains the above brightness information.

The attenuation signal Sc2 is allocated to the latter sub-frame by the signal switching circuit 53, and at the signal line driver 5, an attenuation signal Sc2 with respect to each color is converted into brightness control

potential difference by receiving power feeding from the brightness power source 43. Then, it is transmitted to the relevant pixel in the pixel area Dp and controls the orientation of the liquid crystal molecules at the latter sub-frame.

[0021]

Fig. 6 describes the brightness change found in one pixel as time passes. As shown in Fig. 6, in each frame of the concerned pixel, the brightness of the latter sub-frame is consistently one fourth of that of the former sub-frame. Consequently, it turns out that the higher (brighter) the brightness of an image signal input to one frame is, the larger the difference between the absolute value of brightness and the brightness of the latter sub-frame is.

A moving picture tends to be visually unclear and blurred or disordered especially when a screen is bright. In the LCD of the first embodiment, however, the brightness difference with the latter sub-frame is enlarged in the case of a bright screen. Thereby, it is possible to achieve the same visual effect as with the pseudo impulse system in which the latter sub-frame is not displayed, and prevent the picture from being blurred or disordered and unclear.

[0022]

Furthermore, in accordance with the first embodiment, the latter sub-frame consistently maintains one fourth of the brightness of the former sub-frame, and thus brightness contrast between frames does not vary, and the frame becomes brighter as compared to the pseudo impulse system in which the latter sub-frame is not displayed. Comparing brightness Σ of one frame in the first embodiment

with that of the pseudo impulse system, Σ is expressed as follows:

$$\Sigma = (C+C/F)C$$

wherein the brightness of the former sub-frame is C, and attenuation coefficient is F. That is, assuming that C = 1 and F = 4, then Σ = 1.25, the brightness of one frame in the first embodiment is higher than that of conventional pseudo impulse system by 25%.

[0023]

In the above-mentioned first embodiment, the attenuation coefficient F is fixed to "4". However, the attenuation coefficient F may be a variable [F = f(Sc)] which varies according to the brightness (Sc) of a picture signal input to the relevant frame. For instance, the brightness judging circuit 51 can generate the attenuation coefficient F so that the value of the attenuation coefficient becomes bigger as the input brightness value increases. Depending on how F function is selected, such an LCD is realized as can display the movement more naturally without sacrificing the brightness of the screen.

[0024]

On the other hand, in the above-mentioned first embodiment, when the attenuation coefficient F is fixed as a constant number, it is not necessary for the brightness judging circuit 51 to generate the attenuation coefficient F, and the attenuation signal generating circuit 52 may be provided with a built-in attenuation coefficient generating circuit instead.

[0025]

[Second Embodiment]

The second embodiment shows one example of circuitry for generating an attenuation signal Sc2 for the latter sub-frame by the brightness judging circuit 51 and the attenuation signal generating circuit 52 as shown in Fig. 5.

Fig. 7 describes the circuitry of the second embodiment. Referring to Fig. 7, the brightness judging circuit 51 of the second embodiment, as a circuit for generating the attenuation coefficient F, contains a clock circuit 55 which generates a clock signal to be input to the attenuation signal generating circuit 52. In the second embodiment, the attenuation coefficient signal generating circuit 52 is provided with a shift register.

[0026]

With this circuitry, it is possible to select the attenuation coefficient F by binary number as 2, 4, 8, … as required. More specifically, when the attenuation coefficient F is to be "2", such a clock signal should be generated as has the same clock number as a picture signal and an inverted phase. When the clock signal is input to the attenuation signal generating circuit 52 provided with a shift register, a brightness signal Sc1 composed of a binary series of eight bits moves the digits one place to the right, and the attenuation signal Sc2 with the half brightness of the original brightness signal Sc1 is output from the attenuation signal generating circuit 52.

[0027]

As in the first embodiment, when the attenuation coefficient F is to be "4", such a clock signal should be generated as has a double speed of a picture signal. In

this way, a brightness signal Sc1 shifts two places in the direction of the low order digit, and an attenuation signal Sc2 with the one fourth brightness of the original brightness signal Sc1 is output from the attenuation signal generating circuit 52. For example, letting a brightness signal Sc1 of eight bits be [11111111] with 256 distinct shades on a gray scale, the attenuation signal Sc2 which has shifted by two places to the right becomes [00111111] with 64 distinct shades, and the brightness of the attenuation signal Sc2 becomes one fourth of the brightness signal Sc1.

[0028]

In the same manner, when the attenuation coefficient F is to be "8", such a clock signal should be generated as has a speed four times as fast as a picture signal. In this way, an attenuation signal Sc2 with one eighth brightness of the original brightness signal Sc1 is obtained. In the same way as the above examples, attenuation signals Sc2 with one sixteenth, one thirty-second, … of the brightness of the original brightness signals Sc1 are to be obtained. However, it is not realistic when the attenuation signal Sc2 is extremely small because there is practically no significant difference comparing with the conventional pseudo impulse system.

[0029]

[Third Embodiment]

The third embodiment shows another example of circuitry for generating an attenuation signal Sc2 for the latter sub-frame by the brightness judging circuit 51 and the attenuation signal generating circuit 52 as shown in Fig. 5.

Fig. 8 shows the circuitry of the third embodiment. Referring to Fig. 8, the brightness judging circuit 51 of the third embodiment is provided with a line selecting circuit 56 which generates and outputs a line selection signal SEL at the latter sub-frame according to the designated attenuation coefficient F. The signal switching circuit 53 of the third embodiment is composed of multiplexers MP0 to MP7, which corresponds to eight 8-bit bus lines D0 to D7, respectively.

[0030]

In the third embodiment, a brightness signal Sc1 with eight bits output from the frame buffer 42, at the former sub-frame, goes through the bus lines and passes the attenuation signal generating circuit 52 without being revised. After that, it is transmitted to the signal switching circuit 53 directly, and output to the signal line driver 5 as a brightness signal Sc1 in synchronism with the former sub-frame.

At the latter sub-frame, a brightness signal Sc1 with eight bits, which has been output from the frame buffer 42 over again, goes through the bus lines, and is input to the attenuation signal generating circuit 52. At the same time, the attenuation coefficient F which is determined in advance as a bit-digit number (for example, F will be two bits when the brightness is to be reduced to one fourth) is input to the attenuation signal generating circuit 52, and from the line selecting circuit 56 of the brightness judging circuit 51, a line selection signal SEL corresponding to the attenuation coefficient F (the number of bits) is input to the attenuation signal generating circuit 52.

[0031]

In the attenuation signal generating circuit 52, at the latter sub-frame, based on a line selection signal SEL, a brightness signal, which is input to each of multiplexers MP0 to MP7, or its digits is/ are shifted to the lower place by the number of bits equivalent to the attenuation coefficient F. Signal [0] is input to the blank spaces of the upper order digits (for example, upper two digits), and the lower bits which are overflowed from the multiplexers are truncated. To give a concrete example, as shown in Fig. 9, among 8-bit signals input to the attenuation signal generating circuit 52, only the signals of lower two bits ([0] and [1]) are truncated. The signals of [2] to [7] bits are output as the signals of [0] to [5] bits. The brightness of the output attenuation signal Sc2 becomes one fourth of that of the original brightness signal Sc1.

In the case where the brightness of the subsequent sub-fame is fixed to be one fourth of that of the former sub-frame, the line selecting circuit 56 and multiplexers MP0 to MP7 may be omitted, and what should be done is only to provide a pattern for a circuit in which lines are directly connected, as shown in Fig. 9.

[0032]

[Fourth Embodiment]

The fourth embodiment shows one example of the brightness judging circuit 51 for generating the attenuation coefficient F based on the brightness signal of the entire pixel which forms a picture in one frame.

Fig. 10 shows a circuitry of a brightness judging circuit of the fourth embodiment. The brightness judging

circuit 51 comprises a counter 57 and a comparator 58.

[0033]

Among the brightness signals Sc for respective pixels, which are output from a brightness judging circuit within the brightness judging circuit 51 to bus lines of eight bits, the signals of upper two bits (D7 and D6) are input to the counter 57 separately. This input data is integrated for the entire pixel composing the screen of one frame. The reason for integrating only the upper two bits is to reduce a load on a counter circuit, and also integration of the upper two bits will suffice to judge the brightness of the screen of one frame.

[0034]

The comparator 58 is provided with a threshold value of the brightness of a picture to be a reference. Comparing the threshold value with the integrated value of the brightness of the entire pixel output from the counter 57, the comparator 58 generates different attenuation coefficients F depending on whether the integrated value of brightness exceeds the threshold value (when the entire screen is brighter than the standard) or the integrated value of brightness is below the threshold value (when the entire screen is darker than the standard). The comparator 58 outputs the attenuation coefficients F thus generated to the attenuation signal generating circuit 52.

[0035]

The reason for having the attenuation coefficient F changed by comparison with the threshold value is that the attenuation ratio of the latter sub-frame produces different effects on visual contrast of a picture in the case of a

bright screen and in the case of a dark screen. From this viewpoint, the above-mentioned threshold value and the corresponding attenuation coefficient F are determined experimentally. It is also possible that one designated attenuation coefficient F, in the case of a dark screen, for example, is unloaded, that is, the brightness of the latter sub-frame is not attenuated.

The attenuation coefficient F output from the comparator 58 is input to the attenuation signal generating circuit 52 having one of the circuitry described in the first, the second and the third embodiments in a form suitable for each embodiment.

[0036]

In the LCD of the fourth embodiment, the attenuation coefficient F is determined depending on the overall brightness of a picture in one frame. Therefore, in the case of a bright screen, a visually blurred or disordered picture can be avoided by increasing the attenuation coefficient F so that the latter sub-frame becomes relatively dark, while in the case of a dark screen, visual perception or the visibility of the dark part of the picture can be improved by reducing the attenuation coefficient F so that the latter sub-frame becomes relatively bright. On the other hand, it is also possible for the bright screen to be brighter with a smaller attenuation coefficient, and for the dark screen to be darker with a larger attenuation coefficient. In this way, the dynamic range of contrast can be improved.

[0037]

[Fifth Embodiment]

The fifth embodiment of the present invention shows one example of the brightness judging circuit 51 which outputs an attenuation coefficient changed according to the brightness level of brightness signals.

Fig. 11 shows a circuitry of a brightness judging circuit of the fifth embodiment. The brightness judging circuit 51 comprises a comparator 58 and a RAM 59.

[0038]

The comparator 58 is provided with a plurality of brightness level values such as L1, L2, L3, …. Having been supplied with a brightness signal Sc of each pixel, the comparator 58 compares the signal Sc with each brightness level value, and thereby the appropriate brightness segment for the relevant brightness signal Sc is determined.

[0039]

In the RAM 59, each brightness segment has its special attenuation coefficient F. The RAM 59 distributes the brightness signal Sc, whose brightness segment is designated by the comparator 58, to the designated segment and outputs the relevant attenuation coefficient F which is uniquely set to each brightness segment.

The output attenuation coefficient F is input to the attenuation signal generating circuit 52 with one of the circuitry described in the first, the second and the third embodiments in a form suitable for each embodiment.

The brightness signal Sc input to the comparator 58 may be expressed by pixel unit, or a brightness signal of the entire screen of one frame. In the case of using a brightness signal of the entire screen, as in the fourth embodiment, among brightness signals Sc of respective pixels,

the signals of upper two digits (D7 and D6) are input separately, the input data is integrated for the entire pixel composing the screen of one frame, and the obtained integrated value is input to the comparator 58.

[0040]

The LCD of the fifth embodiment classifies the input brightness signal into the multiple number of brightness segments according to the brightness level, and outputs the attenuation coefficient F whose value is designated in advance to be suitable for the brightness of the segment. Thus, it is possible to carefully select the attenuation coefficient F in consideration of the brightness of a pixel or a screen. As a result, the two contrary factors that suppression of the blur or unclearness of a moving picture between successive frames and securing of picture contrast can be favorably balanced. In this way, the LCD is able to express a moving picture with high visibility or clear visual perception.

[0041]

[Effect of the Invention]

In the display device according to the present invention, the brightness of the subsequent sub-frame is attenuated at a prescribed rate according to the brightness of the picture input, and therefore, it is possible to prevent a moving picture from being visually blurred or disordered and unclear while suppressing a decrease in the brightness of the picture.

[Brief Description of the Drawings]

[Fig. 1]

A schematic plane diagram showing an image display

section of an LCD according to an embodiment of the present invention.

[Fig. 2]

A schematic sectional diagram showing one pixel of the LCD depicted in Fig. 1.

[Fig. 3]

A block diagram showing a means for controlling an image in an LCD according to the first embodiment of the present invention.

[Fig. 4]

A block diagram showing an example of a control device.

[Fig. 5]

A flow diagram showing signal processing.

[Fig. 6]

A graph showing the brightness change found in one pixel.

[Fig. 7]

A block diagram showing an example of a circuitry for generating an attenuation signal.

[Fig. 8]

A block diagram showing another example of a circuitry for generating an attenuation signal.

[Fig. 9]

A circuit diagram showing a mode to generate an attenuation signal.

[Fig. 10]

A block diagram showing an example of a brightness judging circuit.

[Fig. 11]

A block diagram showing another example of a brightness judging circuit.

[Fig. 12]

A graph showing the brightness change of an impulse type display device.

[Fig. 13]

A graph showing the brightness change of a hold type display device.

[Fig. 14]

A graph showing the brightness change of a pseudo impulse type display device.

[Description of Code]

4 Scanning line driver

5 Signal line driver

41 A/D converter

42 Frame buffer

43 Brightness power source

50 Control device

51 Brightness judging circuit

52 Attenuation signal generating circuit

53 Signal switching circuit

55 Clock circuit

56 Line selecting circuit

57 Counter

58 Comparator

59 RAM

[Title of Document]

Abstract

[Abstract]

[Problem] To prevent a moving picture from being unclear, blurred or disordered while suppressing the lowering of the picture brightness.

[Means of Solving] A display device comprises a frame buffer 42 which time-divides a frame displaying one picture into a plurality of sub-frames, an attenuation signal generating circuit 52 which generates an attenuation signal Sc2 by dividing the input brightness signal Sc by a predetermined attenuation coefficient F, and a signal switching circuit 53 which inputs brightness signals Sc1 before division to the antecedent sub-frame in the relevant frame, and inputs the attenuation signals Sc2 after division to the subsequent sub-frame.

[Selected Drawing] Fig. 4

[Title of Document] Drawings

FIG. 1

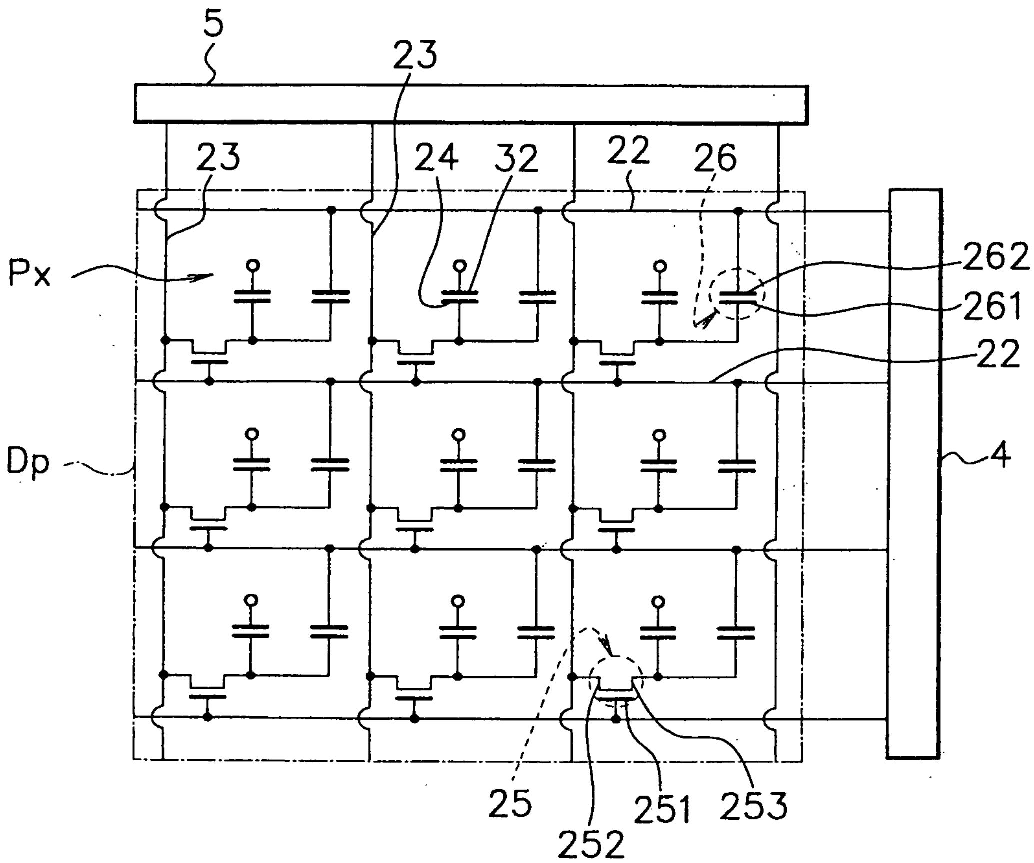
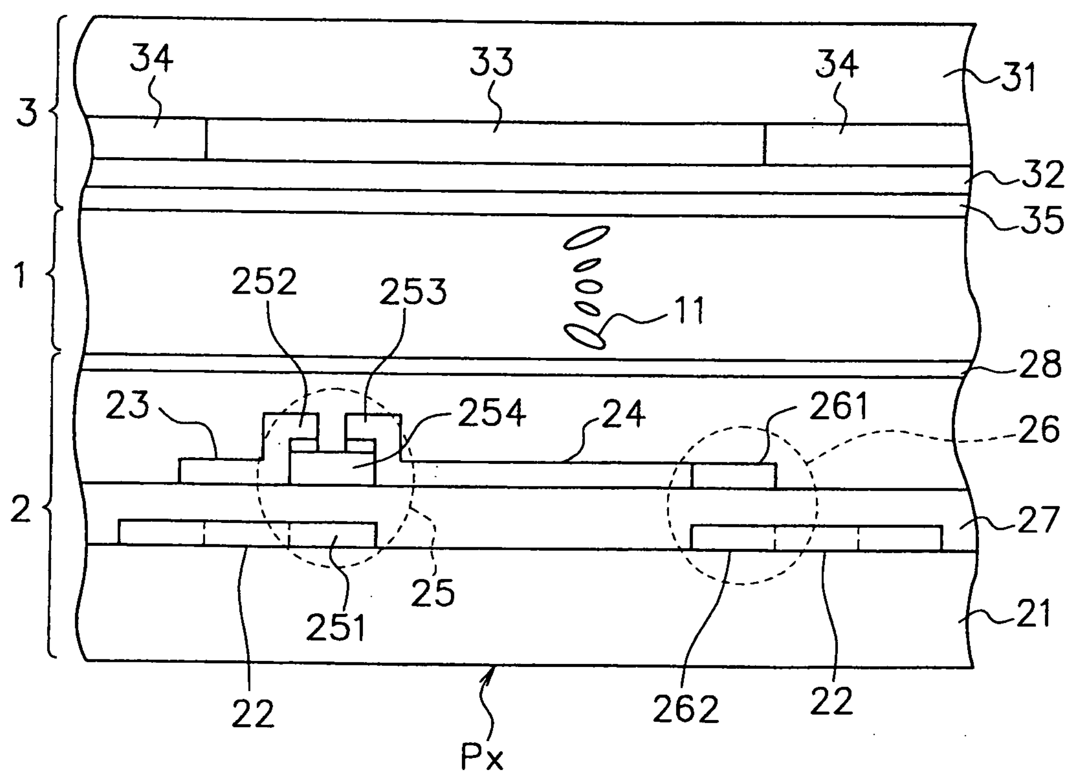


FIG. 2



34
33
34
31
3
32
35
1
252
253
11
28
23
254
24
261
26
2
27
251
25
21
22
262
22
Px

FIG. 3

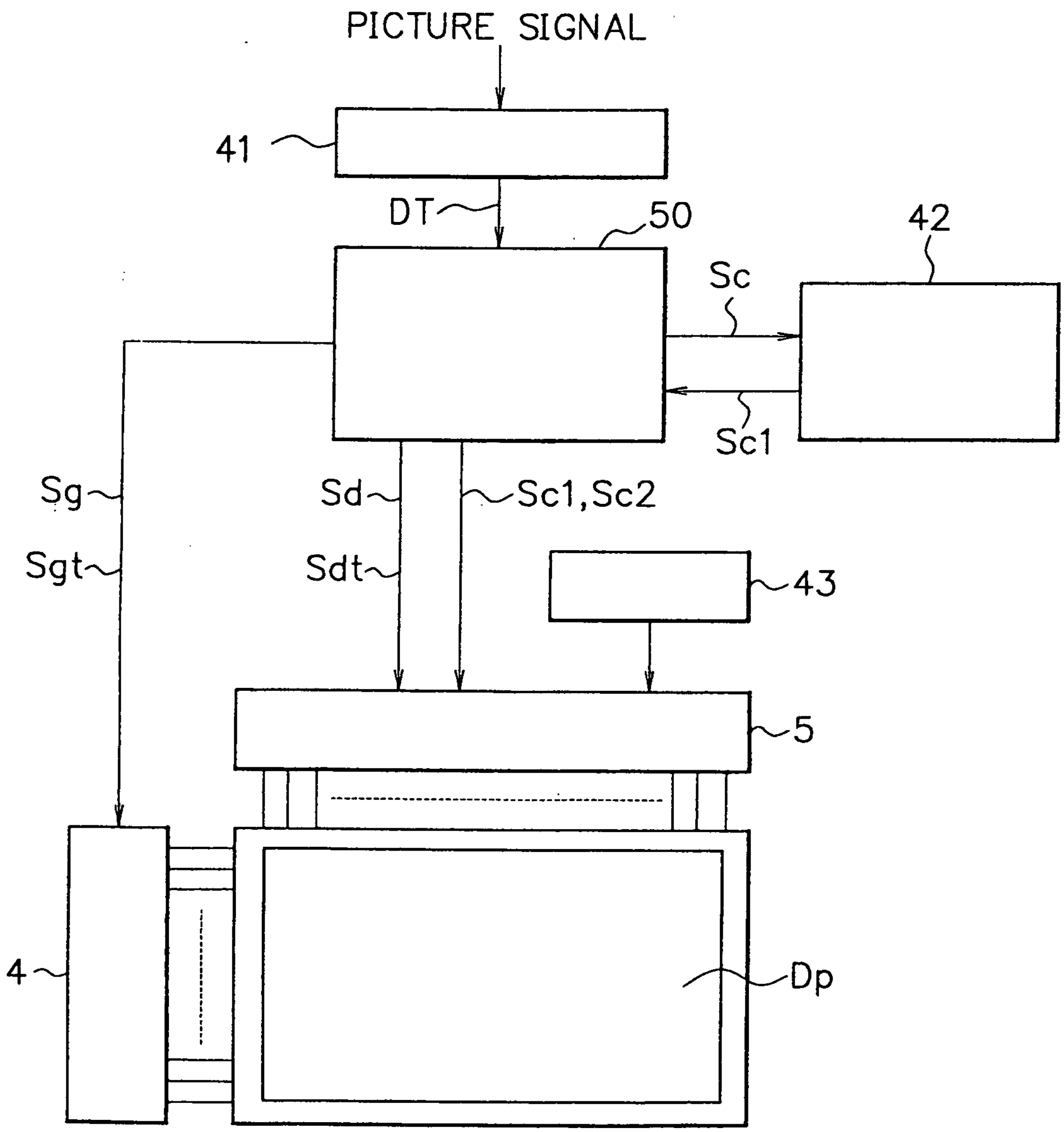


FIG.4

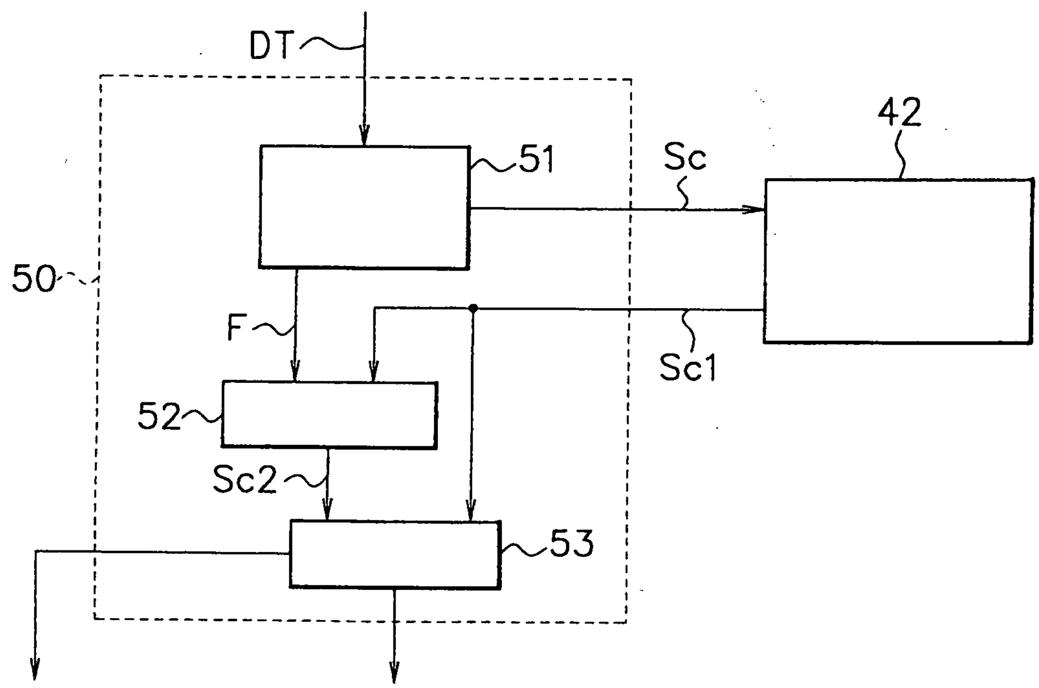


FIG.5

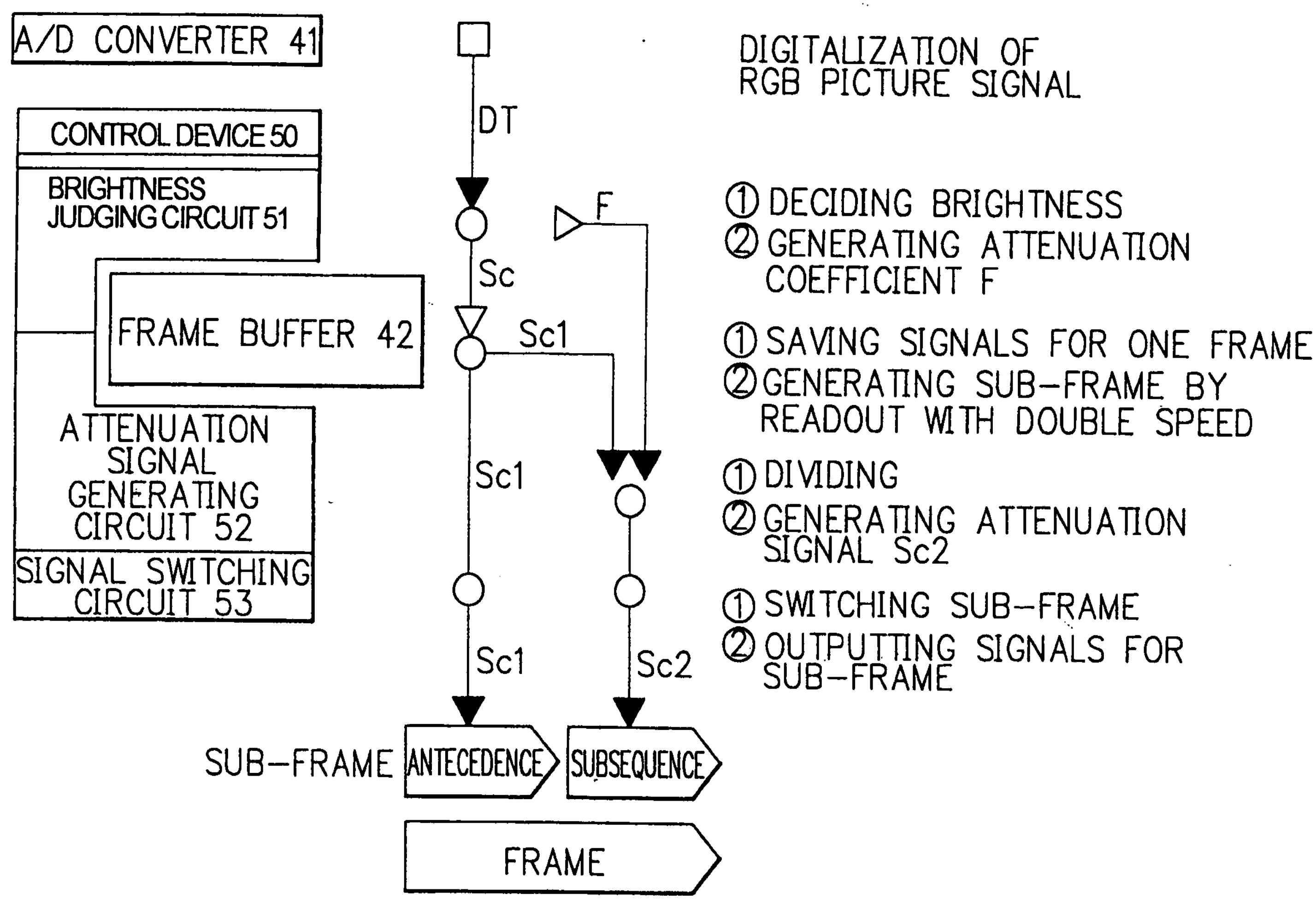

A/D CONVERTER 41
CONTROL DEVICE 50
BRIGHTNESS JUDGING CIRCUIT 51
FRAME BUFFER 42
ATTENUATION SIGNAL GENERATING CIRCUIT 52
SIGNAL SWITCHING CIRCUIT 53
DT
Sc
Sc1
F
Sc1
Sc1
Sc2
SUB-FRAME
ANTECEDENCE
SUBSEQUENCE
FRAME
DIGITALIZATION OF RGB PICTURE SIGNAL
① DECIDING BRIGHTNESS
② GENERATING ATTENUATION COEFFICIENT F
① SAVING SIGNALS FOR ONE FRAME
② GENERATING SUB-FRAME BY READOUT WITH DOUBLE SPEED
① DIVIDING
② GENERATING ATTENUATION SIGNAL Sc2
① SWITCHING SUB-FRAME
② OUTPUTTING SIGNALS FOR SUB-FRAME

FIG.6

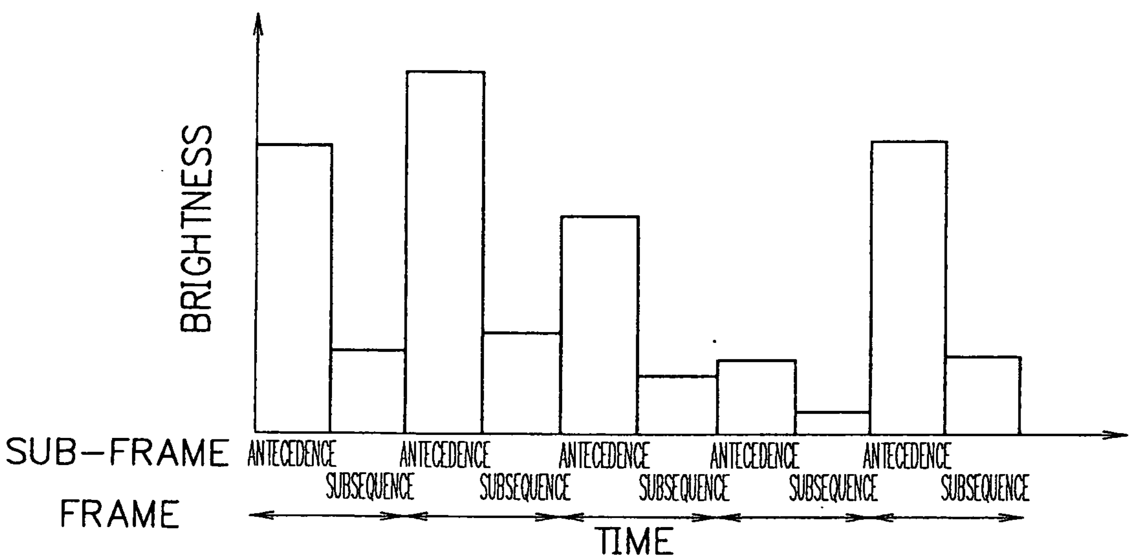

BRIGHTNESS
SUB-FRAME
ANTECEDENCE
SUBSEQUENCE
ANTECEDENCE
SUBSEQUENCE
ANTECEDENCE
SUBSEQUENCE
ANTECEDENCE
SUBSEQUENCE
ANTECEDENCE
SUBSEQUENCE
FRAME
TIME

FIG.7

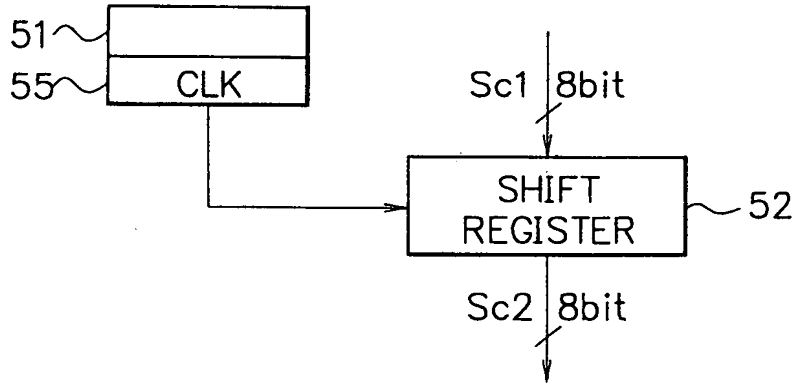

51
55
CLK
Sc1
8bit
SHIFT REGISTER
52
Sc2
8bit

FIG.8

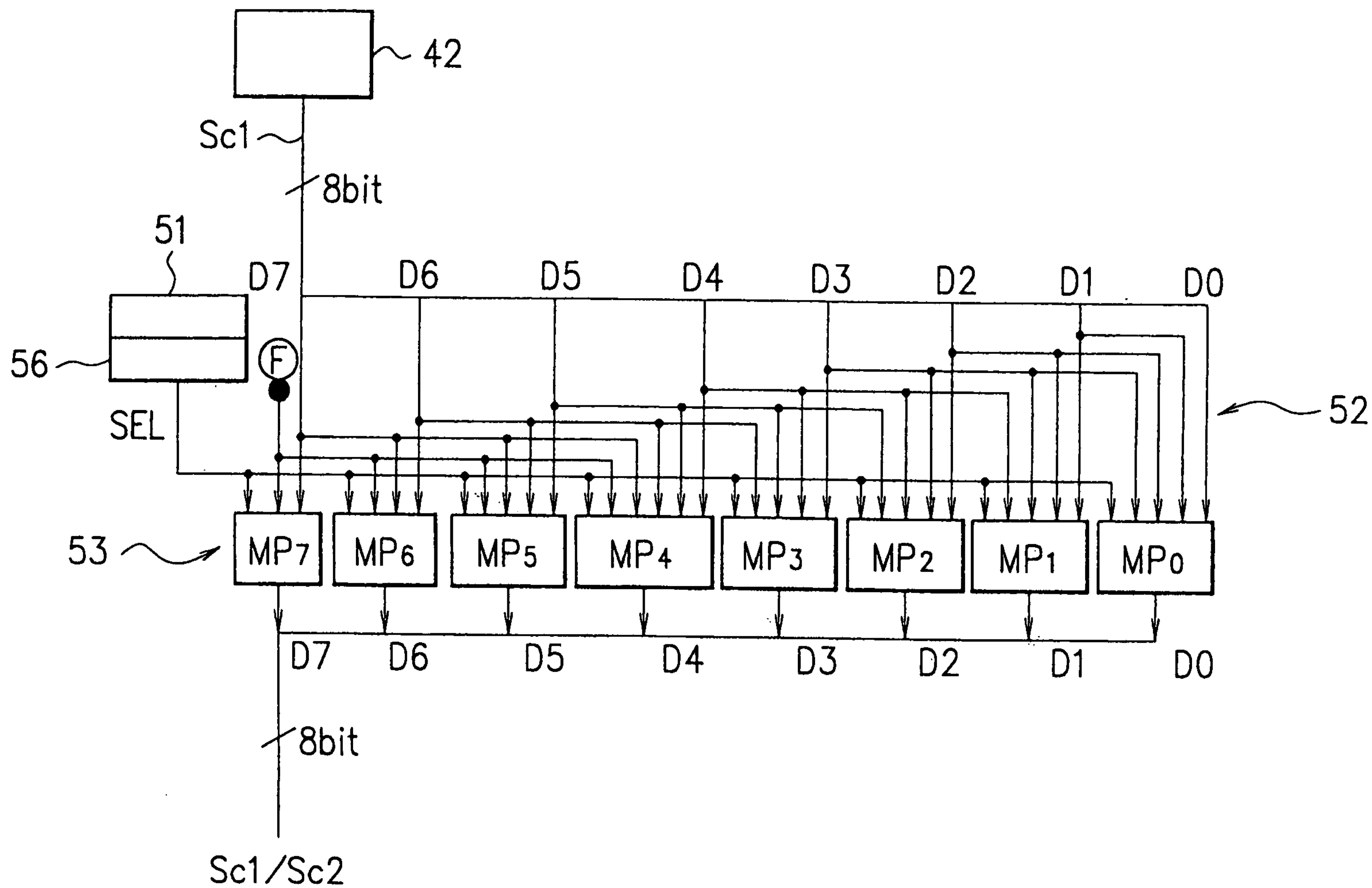

42
Sc1
8bit
51
56
SEL
D7
D6
D5
D4
D3
D2
D1
D0
F
52
53
MP7
MP6
MP5
MP4
MP3
MP2
MP1
MP0
D7
D6
D5
D4
D3
D2
D1
D0
8bit
Sc1/Sc2

FIG.9

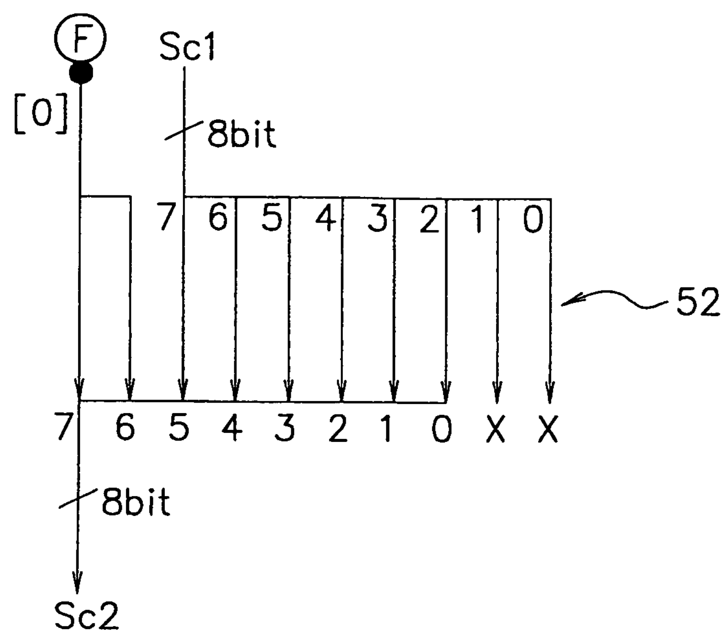

F
Sc1
[0]
8bit
7 6 5 4 3 2 1 0
52
7 6 5 4 3 2 1 0 X X
8bit
Sc2

FIG.10

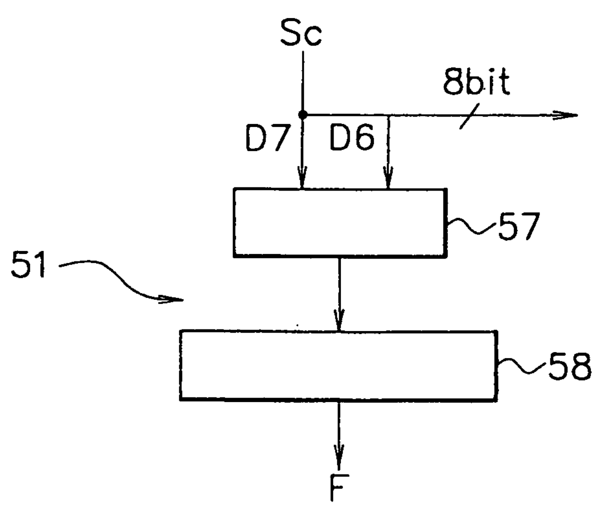

Sc
8bit
D7
D6
57
51
58
F

FIG. 11

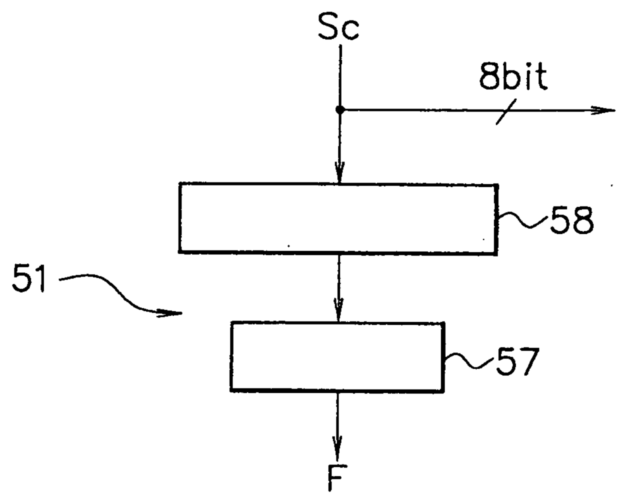


FIG. 12

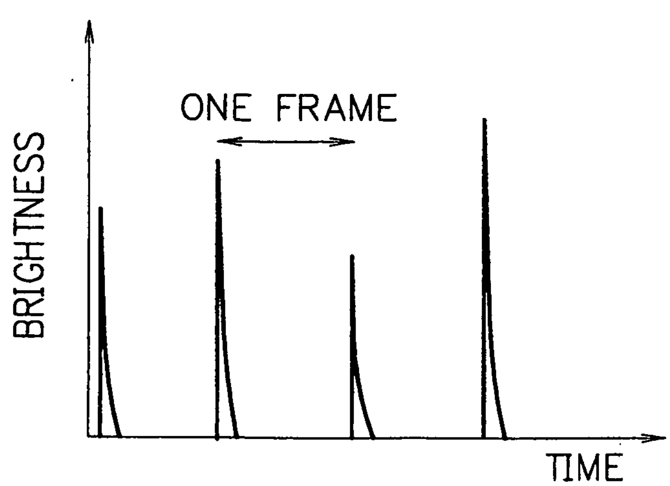


FIG.13

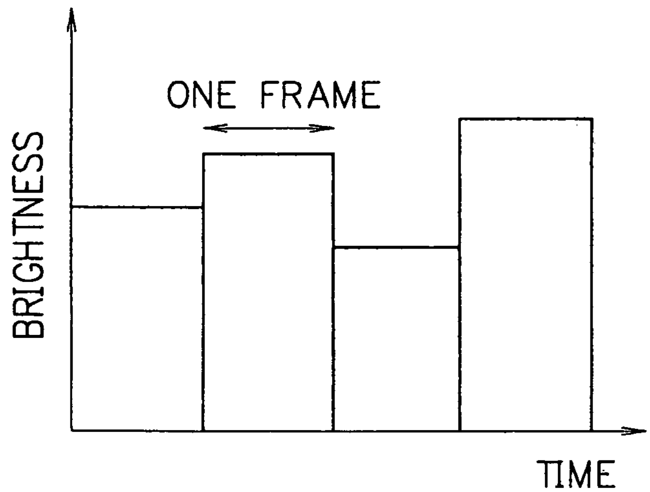


FIG.14